

The Geoscience Laser Altimeter System

Laser Transmitter

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Abstract: The Geoscience Laser Altimeter System (GLAS), scheduled to launch in 2001, is a laser altimeter and lidar for the Earth Observing System's (EOS) ICESat mission. The laser transmitter requirements, design and qualification test results for this space-based remote sensing instrument are presented.

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The Geoscience Laser Altimeter System (GLAS)¹ scheduled to launch in 2001, is the sole instrument for the ICESat (Ice, Cloud and Land Elevation Satellite) mission. GLAS will be a satellite laser altimeter and atmospheric lidar whose primary mission is the global monitoring of the Earth's ice sheet mass balance. GLAS will also provide high precision land topography and global monitoring of aerosols and cirrus cloud heights. The current state-of-the-art in space based solid-state lasers is the Mars Orbiting Laser Altimeter (MOLA)^{2,3}, on the Mars Global Surveyor spacecraft collecting topography data of Mars⁴. The GLAS laser will generally have an order of magnitude higher performance than MOLA in power, beam quality etc., and represents the next generation of space-based remote sensing laser transmitters. The laser transmitter will have the following performance characteristics: pulse energy - 75 mJ @ 1 μm , 35 mJ @ 0.5 μm , repetition rate - 40 Hz, pulse-width < 6 ns, beam divergence - 110 μrad , beam profile - nominally Gaussian, > 4% electrical efficiency, with a 3 year (5 year goal) lifetime (> 3 billion shot lifetime/laser). In addition, the laser must be rugged, reliable and capable of long term operation in the space environment over temperature ranges expected by the instrument.

A master-oscillator, power-amplifier (MOPA) design is the most promising architecture for meeting the transmitter performance objectives⁵. A schematic of the optical layout within the laser housing is shown in Figure 1. The oscillator, pumped by two 100 W Q-cw diode-bars, is passively Q-switched, and generates 2 mJ, 5 ns near diffraction limited ($M^2 < 1.1$) pulses at 40 Hz. The output pulses are expanded by a 2x telescope, and amplified by a double-pass preamplifier stage pumped by 8, 100 W bars resulting in 15 mJ pulses with an $M^2 \approx 1.4$. This stage utilizes a polarization coupled double pass zig-zag slab with a porro prism for beam symmetrization. After another 2x expansion, the beam enters a power amplifier pumped by 44, 100 W bars. The pulses are amplified to 110 mJ after a double pass with an $M^2 \approx 1.8$. The peak laser fluence in the final amplifier is 4 J/cm². The full power beam is then directed to a Lithium Triborate doubler designed to convert 30% of the power into the green, followed by an achromatic, 6x final beam expander. Figure 2 shows the output energy and prime power draw by the diode power supply as a function of diode drive current. To improve laser lifetime⁶ oscillator diodes are derated to 65 W/bar (85 A) and the amplifier diodes are derated to 85 W/bar (100 A)⁷. The laser is all conductively cooled with the thermal interface to the spacecraft being a heat pipe mounted to a side-wall of the laser housing. Thermal

control of the oscillator diodes and the doubling crystal must be accommodated and accounted for internally to the laser leading to a final prime power draw of 110 W @ 30V input.

All materials and construction techniques have been carefully considered to ensure radiation tolerance, vacuum compatibility and opto-mechanical stability. Our preflight, vacuum compatible, engineering test unit (ETU) weighing 14.7 kg, has undergone thermal-vacuum (TVAC) tests over multiple survival and operational cycles from 0 to 40 °C and 10 to 30 °C respectively, with no change in the laser performance after testing. The ETU has also passed vibration testing at 10.6 grms simulating launch conditions, demonstrating the design is ready for flight fabrication.

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Reference:

- 1 Abshire, J.B, X. Sun, E. A. Ketchum, R. S. Afzal, P. S. Millar. "The Geoscience Laser Altimeter System (GLAS) for the ICESat Mission", *OSA Conference on Lasers and Electro-Optics*, San Francisco, CA, May 2000.
- 2 Afzal, R. S., "Mars Observer Laser Altimeter: Laser Transmitter," *Applied Optics*, (33), 15, 20 May, 1994, p. 3184
- 3 Afzal, R. S., "Space Operation of the MOLA Laser", OSA Advanced Solid State Laser Topical Meeting, Davos, CH, 2000.
- 4 Smith, D.E., M.T. Zuber, H.V. Frey, J.B. Garvin, J.W. Head, D.O. Muhleman, G.H. Pettengill, R.J. Phillips, S.C. Solomon, H.J. Zwally, W.B. Banerdt, T.C. Duxbury, Topography of the northern hemisphere of Mars from the Mars Orbiter Laser Altimeter. *Science*, Vol. 279, pp. 1686-1692, 1998.
- 5 Afzal, R. S., A. W. Yu, W. A. Mamakos, "The GLAS Laser Transmitter Breadboard", OSA TOPS Vol. 10, Advanced Solid State Lasers, p. 102 Orlando, FL, Jan. 27 - Jan. 29, 1997
- 6 Stephen, M. A, J. L. Dallas and R. S. Afzal, "Multi-billion shot, High-Fluence Exposure of Cr4+:YAG Passive Q-switch," *SPIE Proceedings from 29th Annual Boulder Damage Symposium*, Vol. 3244, Boulder, CO, p. 517, Oct. 6, 1997.
- 7 Stephen, M. A., M. Krainak, and J. L. Dallas, "Quasi-CW Laser Diode Bar Life Tests," *SPIE Proceedings from 29th Annual Boulder Damage Symposium*, Vol. 3244, Boulder, CO, p. 598, Oct. 6, 1997.

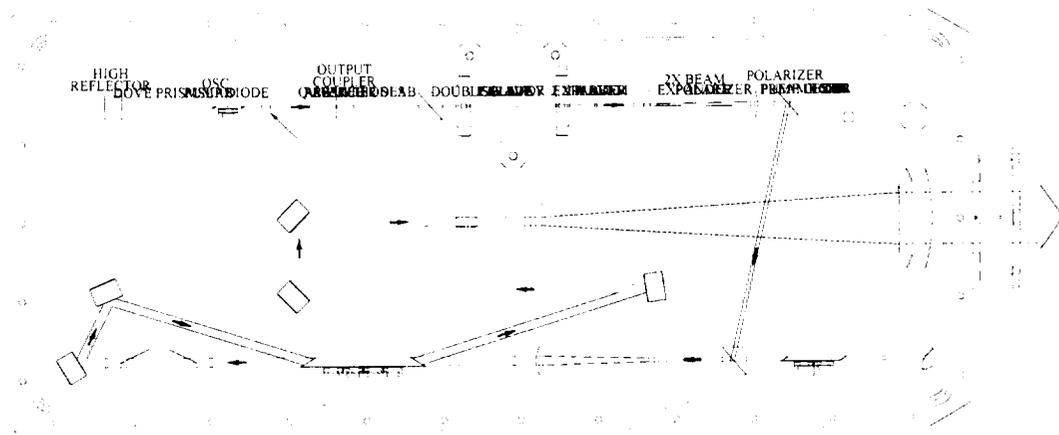


Figure 1 – Schematic of the optical layout in the GLAS laser housing.

GLAS Laser Breadboard

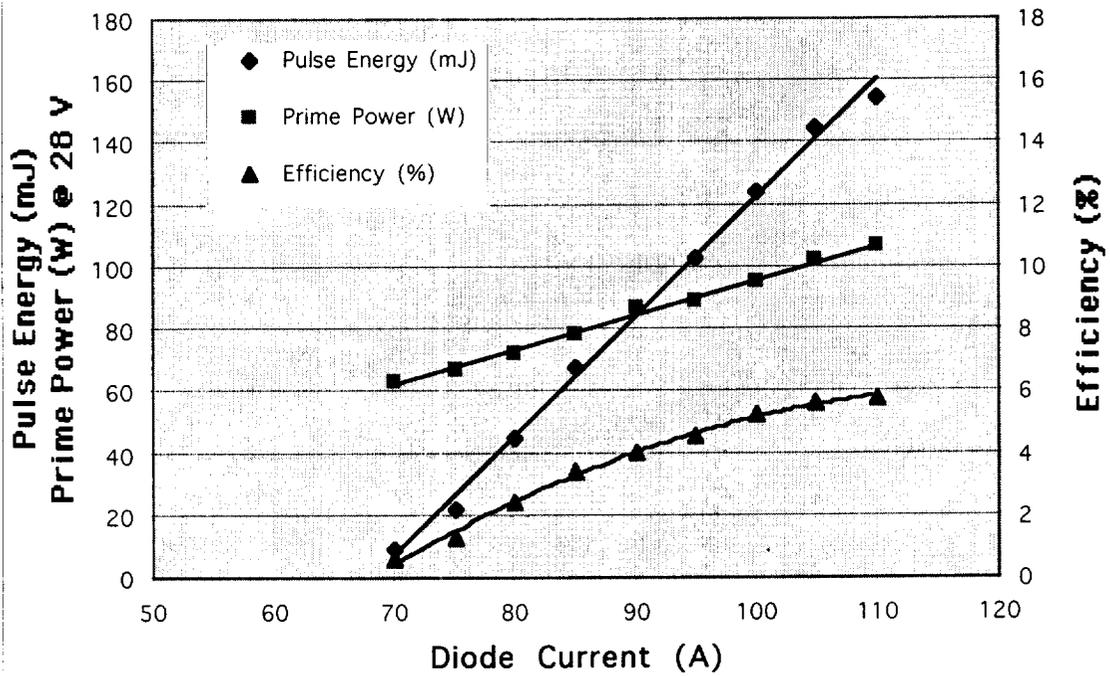


Figure 2 – Output pulse energy (at 40 Hz) as a function of diode drive current. Also shown are the prime power usage from the diode power supply and the efficiency. This graph shows the laser architecture is capable of 160 mJ pulse with the diodes operating at full power. The GLAS laser diodes are derated to 100 A during operation.